

**Southeastern Transportation Center
 Proposal Cover Page
 O/E Grant 2017-2018**

UNIVERSITY:	University of Central Florida	
TITLE OF PROJECT:	Disaster Analytics: Disaster Preparedness and Management through Online Social Media	
FEDERAL FUNDS:		
Requested Amount	Proposed Duration: 18 months	Desired Start Date: 01/01/2017
\$ 49,771		
MATCHING FUNDS:		
Source 1: Internal funding	Source 2:	
\$49,771	\$	
DEPARTMENT SUBMITTING PROPOSAL:		
PI Name/Title: Dr. Samiul Hasan, Assistant Professor		
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Fax:		
Email: Samiul.Hasan@ucf.edu		
Signature: 	Date: 11-03-2016	
SUBCONTRACTING INSTITUTION:		
ADMINISTRATIVE REPRESENTATIVE AUTHORIZED TO CONDUCT NEGOTIATIONS:		
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Email: Julia.Capoverdi@ucf.edu		
Signature: Not required	Date:	
ADMINISTRATIVE ORGANIZATION'S REPRESENTATIVE:		
Name/Title: Felecia Baboolall, Proposal Coordinator		
Address: 12201 Research Parkway Suite 501, Orlando, FL 32826		
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OTHER REQUIRED SIGNATURES:		
Name/Title: Matt Cronan, Sr. Proposal Manager		
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Problem Statement

Over the last decade, an increasing number of natural disasters have adversely affected critical infrastructures, regional economies, and millions of people all over the world (Guha-Sapir et al. 2013; Sundermann et al. 2013). In particular, our cities have become more vulnerable because of increasing population growths and greater concentration of critical infrastructures and operations; many of them are located in coastal areas naturally vulnerable to major disasters (Hasan & Foliente 2015). From the evidence of the recent disasters in the United States such as hurricanes Sandy and Matthew it is clear that the risks of severe and widespread impacts from these disasters have never been greater in society than today (Samenow & Fritz 2016).

A National Research Council report, “**Disaster Resilience: A National Imperative**” has defined community resilience as “the ability to prepare and plan for, absorb, recover from, and more successfully adapt to actual or potential adverse events” (National Research Council 2012, p 27). To chart a path towards resilience, the report has set a few guiding principles one of which states that residents should understand their disaster risks and take individual preparations to mitigate those risks. Thus to promote resilience minimizing the adverse impacts of disasters, instead of being reactive, communities need to be proactive (Cutter et al. 2013).

During a disaster, disseminating information effectively and timely plays a critical role in spreading awareness in a community. It requires a range of delivery techniques to reach the target audience using different media and communication means. Online social media (such as Facebook, Twitter) can serve as alternative channels to disseminate information to a wider audience. They have become mainstream communication platforms providing an unprecedented opportunity to analyze, model and predict various social phenomena during disasters (Lazer et al. 2009). **Crisis informatics** or **disaster analytics** is an emerging interdisciplinary field that develops computational approaches to extract, analyze, and predict online activities (i.e., tweets and Facebook posts) to address challenges in disaster warning, response, and recovery operations (Palen & Anderson 2016). Applications of such data analytics can be found in many recent studies using social media data during disasters (Kryvasheyev et al. 2014; Thom et al. 2016; Sadri, Hasan, Ukkusuri, et al. 2016; Sadri, Hasan & Ukkusuri 2016).

As disaster analytics is a relatively new field investigating the role of social media during disasters, most studies commonly focus on high-level correlations among the variables of interest when analyzing large-scale data sets (Palen & Anderson 2016). However, many other questions (Gladwin et al. 2007; Murray-Tuite & Wolshon 2013) about behavioral and social phenomena, critical to achieving disaster resilience, still remain open. Large data sets from the ubiquitous social media systems can answer questions such as:

- How can we use social media communications to rapidly identify infrastructure disruption issues and monitor disaster responses and recovery efforts?

- How can we measure the effectiveness of the available information sources in warning message propagation using the topological properties of the social network observed?

The goal of the proposed project is to develop data analytics approaches for social media data in a disaster management context. A particular focus of the project will be to characterize the emerging online disaster communication networks which play a critical role improving emergency situational awareness including risk communication, warning propagation, and decision making. Studies have found that social factors are important in translating hazard warning into collective decisions (Hasan & Ukkusuri 2011). Social media can play an alternative role for information sharing establishing self-organized disaster communication networks. In this context, a large volume of data is generated by the users when sharing about different aspects of a disaster, hurricane Matthew is the most recent one. However, research is needed to analyze this data inferring various patterns and behavior to gain deeper insights on user behavior during a disaster.

The proposed project contributes to the emerging field of disaster analytics by developing computational approaches for social media data. As the recent studies using social media data have not investigated beyond high level correlations, many open questions related to the behavioral and social aspects of disaster communications in social media are yet to be answered. Within this context, the main goal of this project is to develop methods to characterize disaster communication networks. *First*, text analysis methods will be developed, based on probabilistic topic models, to characterize the contents of social communications during disasters. *Second*, different subgraphs will be created based on user activities and social connections present in social media and the structural properties of the subgraphs will be analyzed using the concepts of network science.

Understanding the role of social media during disasters will help emergency managers and transportation officials to effectively communicate risks among users, measure and accelerate evacuation warning propagation, and monitor disaster response and recovery efforts in a cost-effective way. Social media activities will enable a rapid identification of infrastructure disruption issues (e.g., signal failures, tree falls on roads, flooding etc.) and continuous monitoring of disaster responses and recovery activities. Emergency managers can use disaster communication networks to reach vulnerable people with more relevant information. An efficient propagation of warning messages is critical to disaster management. Understanding the structural and behavioral properties of disaster communication networks thus will allow emergency managers to run efficient social media channels giving evacuation notices. Thus a deeper knowledge about the emerging online disaster communications and the associated networks will help us to design various decision making tools supporting a disaster resilient community.

Research Objectives

In this project, a set of computational methods will be developed to collect, analyze, and model online social media activities in the context of a disaster. With the developed methods, we will be able to identify different issues faced by a community and monitor disaster recovery efforts. The proposed approaches will also help us to understand disaster communication networks and modeling different processes within such networks. The proposed project has three specific objectives:

- Gather disaster communications data from a popular social media platform (i.e. Twitter).
- Develop text analysis methods to characterize the contents of social media posts during disasters.
- Develop network analysis methods to understand the structural properties of the underlying disaster communication networks.

Research Approach

To achieve the objectives of the proposed project, five major tasks have been identified. Each task will consist of development of tools or methods for social media data.

Task 1 Review on Social Media in Disaster Management

An extensive literature search will be conducted to review a) the emerging role of social media in disaster communication and management and b) analytics approaches developed to process and analyze social media data. Based on the review potential scopes of social media in disaster communication and management and state-of-the-art analytics methods for social media data will be identified and presented.

Task 2 Data Gathering and Initial Processing

In this part of the project, data over different disasters will be collected from Twitter. A script has been written and run to collect Twitter posts about the recent hurricane Matthew across the states of Florida, Georgia, South Carolina, and North Carolina. Using these scripts, the research team has already collected a substantial amount of Twitter data during **hurricane Matthew**. To clean these datasets for running the approaches developed in the next tasks, processing scripts will be written. To collect the network data a separate crawling program will be developed using Twitter's API. Due to the restrictions from Twitter a user is allowed to download a limited number of Tweets with a given time period. To avoid any missing Tweets, the PI will explore purchasing relevant datasets from Twitter.

Task 3 Geo-coding and Relevance Filtering

Typically, only a small percentage of the tweets have location information. In this part of the project, additional information will be extracted from user profiles to geo-code the tweets. This

step will be important to identify the tweets which are geographically relevant to the hurricane path and the affected regions. Multiple filtering mechanisms will be tested on the data to gather relevant datasets.

Task 4 Developing Text Analytics

Previous work (Kryvasheyev et al. 2014) did not analyze the contents of the Tweets to understand the related issues faced by the communities/users. In this part of the project, a series of models will be developed to analyze the contents of Tweets. Based on topic modeling approach (Hasan & Ukkusuri 2014), we will develop a model that can infer well-defined patterns of user issues during disasters at an aggregate level. To capture individual realizations of the issues we will build a user-specific version of the model. Finally, to account for community-level issues, a model will be developed that can jointly infer user communities and the pattern of reported issues by considering user connectivity and topics of issues. Community-level topics will be critical to determine the variety of issues faced by different communities in the disaster affected regions.

Task 5 Developing Network Analytics

Previous works on social media in disaster management did not consider the dynamics of connectivity and contents shared in online social media. In this part of the project, a dynamic network analysis tool will be developed. From the information on connections collected from Twitter, a network of users will be created. Based on the concepts of Network Science (Kane et al. 2014), a set of properties will be estimated. We will also define time-dependent subgraphs based on user activity levels and measure the network properties for each of the time-dependent subgraphs. Finally, we will investigate the association between the structural properties and different topics of issues determined in the text analysis task.

Task 6 Preparation of Final Report

The research team will submit quarterly reports describing the progress of the project and a final report. This final report will contain a summary of the literature review, methods developed, major findings from the study, a set of recommendations for transportation agencies planning to use social media tools for disaster management, major challenges and future research needs.

The proposed schedule, timeline and milestones of the project are given in page 9.

Research Duration and Cost

The proposed project will be one and half year long (**18 months**) starting from January 1, 2017 to June 30, 2018.

The required cost of the project has been estimated as **\$99,542 USD** with 50 percent of the cost matched by UCF through the PI's startup budget.

Qualifications of Research Team

The proposed project will be led by Dr. Samiul Hasan with assistance from a graduate research assistant and an undergraduate student intern. Dr. Hasan has recently joined as an Assistant Professor to the Department of Civil, Environmental and Construction Engineering at the University of Central Florida (UCF). Dr. Hasan is an expert in data analytics, big data, network modeling, evacuation modeling, and machine learning. He completed his PhD from Purdue University under a Fulbright Science & Technology fellowship. In 2014, INFORMS TSL society awarded him the best dissertation prize, one of the most prestigious honors for doctoral dissertations in the field of transportation science and logistics. Dr. Hasan has extensive experiences of working on data analytics, machine learning and urban systems modeling research at MIT, Purdue, Transport for London, UK and CSIRO, Australia. He has a strong publication record of 17 journal articles, 12 conference papers, 1 book chapter, and 2 technical reports. He has more than 450 Google Scholar citations with an *h*-index of 12.

Dr. Samiul Hasan has an extensive experience of working with social media data. He has developed several data analytics approaches to understand human mobility and activity choice behavior from social media data. His work on geo-location data from social media presented a novel approach for activity-based mobility modeling. He has also worked on evacuation behavior modeling and agent-based simulation of hurricane evacuation.

Relevant Publications of PI

- Sadri, A.M., **Hasan, S.**, Ukkusuri, S. V, Cebrian, M. 2016. Exploring Active Twitter Subgraphs to Understand the Disaster Communication Network of Hurricane Sandy. Working paper.
- **Hasan, S.** and Ukkusuri, S. V. 2015. Location contexts of user check-ins to model urban geo life-style patterns. *PloS one* 10(5), e0124819.
- **Hasan, S.**, Ukkusuri, S. V., Gladwin. H., and Murray-Tuite, P. 2011. Behavioral model to understand household-level hurricane evacuation decision making. *ASCE Journal of Transportation Engineering* 137(5), 341-348.
- **Hasan, S.** and Ukkusuri, S. V. 2011. A threshold model of social contagion process for evacuation decision making. *Transportation Research Part B-Methodological*, 45(10), 1590–1605.

Student Involvement

One graduate student and one undergraduate student intern will assist the PI of the project. The graduate student will be assisting the PI in collecting social media data, implementing and running the text and network analytics methods and conducting experiments using the developed methods. The undergraduate student intern will help the research team in data cleaning and processing tasks. Recruitment from underrepresented groups, e.g., women and minorities, will be sought.

Technology Transfer

The research team will help disseminating the research results by publishing technical papers, presenting the results at the TRB annual meeting, and submitting a final report to STC. An article that covers the entire study will be submitted to the Transportation Research Board for consideration of publication and presentation. Other academic journals, such as Natural Hazards, ASCE Journal of Transportation Engineering/ Natural Hazards Review, Transportation Research Part A: Policy and Practice, Transportation Research Part C: Emerging Technologies, and conferences related to disaster management will be considered to disseminate various portions of the research efforts. A reasonable amount of travel budget (\$5000 for one and half years) has been allocated to disseminate the outcomes of this research through attending conferences.

Table 1 Description of Final Products

<i>Final Product</i>	<i>Tasks Covered</i>
Social media data collection and processing scripts	Task 2-3
Social media text analytics tool	Task 4
Social media network analytics tool	Task 5

References

- Cutter, S.L. et al., 2013. Disaster Resilience: A National Imperative. *Environment: Science and Policy for Sustainable Development*, 55(2), pp.25–29.
- Gladwin, H. et al., 2007. Social Science Research Needs for the Hurricane Forecast and Warning System. *ASCE Natural Hazards Review*, 8(3), pp.87–95.
- Guha-Sapir, D., Hoyois, F. & Below, R., 2013. *Annual Disaster Statistical Review 2012: The Numbers and Trends*, Brussels, Belgium.
- Hasan, S. & Foliente, G., 2015. Modeling infrastructure system interdependencies and socioeconomic impacts of failure in extreme events: emerging R&D challenges. *Natural Hazards*, 78(3), pp.2143–2168.
- Hasan, S. & Ukkusuri, S. V., 2011. A threshold model of social contagion process for evacuation decision making. *Transportation Research Part B-Methodological*, 45(10), pp.1590–1605.
- Hasan, S. & Ukkusuri, S. V., 2014. Urban activity pattern classification using topic models from online geo-location data. *Transportation Research Part C: Emerging Technologies*, 44, pp.363–381.
- Kane, G., Labianca, G. & Borgatti, S.P., 2014. What’s Different About Social Media Networks? A Framework and Research Agenda. *MIS Quarterly*, 38(1), pp.274–304.
- Kryvasheyev, Y. et al., 2014. Performance of Social Network Sensors During Hurricane Sandy. *PLoS ONE*, 10(2), pp.1–19.
- Lazer, D. et al., 2009. Life in the network: the coming age of computational social science.

- Science*, 323(5915), pp.721–723.
- Murray-Tuite, P. & Wolshon, B., 2013. Evacuation transportation modeling: An overview of research, development, and practice. *Transportation Research Part C: Emerging Technologies*, 27, pp.25–45. Available at: <http://dx.doi.org/10.1016/j.trc.2012.11.005>.
- National Research Council, 2012. *Disaster Resilience: A National Imperative*, Available at: <http://www.nap.edu/catalog/13457>.
- Palen, L. & Anderson, K.M., 2016. Crisis informatics—New data for extraordinary times. *Science*, 353(June), pp.224–225.
- Sadri, A.M., Hasan, S., Ukkusuri, S. V, et al., 2016. Exploring Active Twitter Subgraphs to Understand the Disaster Communication Network of Hurricane Sandy. In *Submitted to Transportation Research Board Conference*. pp. 1–24.
- Sadri, A.M., Hasan, S. & Ukkusuri, S. V, 2016. *Joint Inference of User Community and Interest Patterns in Social Interaction Networks*,
- Samenow, J. & Fritz, A., 2016. Horrific rains and ocean surge: Hurricane Matthew by the numbers. *The Washington Post*. Available at: https://www.washingtonpost.com/news/capital-weather-gang/wp/2016/10/11/horrific-rains-and-ocean-surge-hurricane-matthew-by-the-numbers/?hpid=hp_hp-top-table-low_cwg-matthewnumbers-100pm%3Ahomepage%2Fstory.
- Sundermann, L., Schelske, O. & Hausmann, P., 2013. *Mind the risk – A global ranking of cities under threat from natural disasters*, Zurich: Swiss Reinsurance Company Ltd.
- Thom, D., Krüger, R. & Ertl, T., 2016. Can twitter save lives? A broad-scale study on visual social media analytics for public safety. *IEEE Transactions on Visualization and Computer Graphics*, 22(7), pp.1816–1829.

STC Research Schedule/Timeline

Task / Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Task 1 Review on Social Media in Disaster Management	1																	
Task 2 Data Gathering and Initial Processing																		
Task 3 Geo-coding and Relevance Filtering						2												
Task 4 Developing Text Analytics								3										
Task 5 Developing Network Analytics													4					
Task 6 Preparation of Final Report																5		

Project Milestones

<i>Milestone</i>	<i>Deliverables/Products</i>	<i>Date of Completion</i>
1	Literature review	End of Month 3
2	Completion of data cleaning and processing scripts	End of Month 7
3	Completion of text analytics	End of Month 11
4	Completion network analytics	End of Month 15
5	Final Report	End of Month 18

STC Research Project Description

Project Title: Disaster Analytics: Disaster Preparedness and Management through Online Social Media
Principal Investigator: Dr. Samiul Hasan
University: University of Central Florida
Telephone: 407-823-2480 **Email Address:** Samiul.Hasan@ucf.edu

External Project Contact (if applicable):

Address Street:

City:

State:

Zip:

Telephone:

Email Address:

Project Start Date: 01-01-2017

End Date: 06-30-2018

Other Milestones, Dates:

#1 Literature review, end of month 3.

#2 Completion of data cleaning and processing scripts, end of month 7.

#3 Completion of text analytics, end of month 11.

#4 Completion of network analytics, end of month 15.

#5 Final report, end of month 18.

Project #:

Project Objective:

- Gather disaster communications data from a social media platform (i.e. Twitter).
- Develop text analytics to analyze the contents of social media posts during disasters.
- Develop network analysis methods to understand the structural properties of the underlying disaster communication networks.

Project Abstract:

Online social media can serve as alternative means to disseminate information during a disaster. The goal of the proposed project is to develop analytics approaches for social media data in a disaster management context. In this project, text and network analysis methods will be developed to characterize the content and associated network of social media communications. Understanding the role of social media during disasters will help emergency managers and transportation officials to communicate risks among users and monitor disaster response and recovery efforts in a cost-effective way.

Task Description:

Task 1 Review on Social Media in Disaster Management; Task 2 Data Gathering and Initial Processing; Task 3 Geo-coding and Relevance Filtering; Task 4 Developing Text Analytics; Task 5 Developing Network Analytics; and Task 6 Final Report Preparation

Total Budget: \$ 99,542

Student Involvement (Thesis, Assistantships, Paid Employment):

One graduate research assistant and one undergraduate student will be involved in the project.

Relationship to Other Projects:

N/A

Technology Transfer Activities:

The findings of the project will be disseminated through journal papers and conference presentations.

Potential Benefits of Project:

The project will help building alternative tools for transportation officials and emergency managers to manage evacuations and disaster response and recovery operations in a better and cost-effective way.

TRB Keywords:

Social Media; Disasters and emergency operations; Emergency management; Information Dissemination; Evacuation; Hurricanes.

PEER REVIEW FORM

Peer Reviewer #1

Name:	Pamela Murray-Tuite, Ph.D.
Organization/University Affiliation:	Associate Professor, Department of Civil and Environmental Engineering, Virginia Tech
Address:	7054 Haycock Road Falls Church, VA 22043
Phone #:	(703) 538 - 3764
Fax #:	
Email address:	murraytu@vt.edu
Please submit a brief overview of why this individual is qualified to review the material.	
Qualifications of reviewer: Dr. Murray-Tuite is an expert in hurricane evacuation and disaster management. She has authored many publications on hurricane evacuation modeling. She is also the associate editor of Transportation Research Part C overseeing evacuation related papers.	

Peer Reviewer #2

Name:	Taha Hossein Rashidi
Organization/University Affiliation:	Senior Lecturer, School of Civil and Environmental Engineering, University of New South Wales, Australia
Address:	Civil Engineering Building (H20) Level 1, Room CE113 Kensington Campus
Phone #:	+61 2 9385 6139
Fax #:	
Email address:	rashidi@unsw.edu.au
Please submit a brief overview of why this individual is qualified to review the material.	
Qualifications of reviewer: Dr. Rashidi is an expert on travel behavior modeling. He has published several papers on the use of social media data for travel behavior modeling.	

Peer Reviewer #3

Name:	Qing He
Organization/University Affiliation:	Assistant Professor, Transportation Engineering and Logistics, University of Buffalo, SUNY
Address:	313 Bell Hall and 225 Ketter Hall Buffalo, NY 14260
Phone #:	(716) 645-3470
Fax #:	
Email address:	qinghe@buffalo.edu
Please submit a brief overview of why this individual is qualified to review the material.	
Qualifications of reviewer: Dr He is an expert in social media data collection and data mining. He has investigated social media data for understanding planned and unplanned events and published several papers on this topic.	

*Two peer reviewers will be selected for each final report. Other appropriate reviewers may be selected at the discretion of the STC.

**Southeastern Transportation Center
Proposed Budget
O/E Grant 2017-2018**

Title: Disaster Analytics: Disaster Preparation and Management through Online Social Media

University: University of Central Florida

		Federal Funds	Matching Funds
Salaries:			
Faculty		9,248	9,248
Administrative Staff			
Other Staff			
Graduate Student Salaries/Stipends		15,756	15,756
Undergraduate Student Salaries/Stipends		1,583	1,583
Total Salaries/Stipends			
Benefits (including student health insurance)		2,790	2,790
Total Salaries and Benefits		29,377	29,377
Other Direct Costs:			
Permanent Equipment			
Expendable Equipment and Supplies		2,000	2,000
Non-salary Education Costs – tuition/fees		7,716	7,716
Other Costs: (specify)			
Printing / duplication			
Postal expense			
Communication			
Conference Registration / Fees			
Travel		2,000	2,000
Computer Costs			
Other miscellaneous costs:			
Total Other Direct Costs		9,716	9,716
Indirect Costs at 26%		8,678	8,678
TOTAL COSTS		49,771	49,771

Résumé of Samiul Hasan, PhD

Area(s) of Specialization

Urban Data Science, Human Mobility, Social Media, Big Data Analytics, Machine Learning, Network Modeling, Agent-Based Simulation, and Disaster Management.

Education

Doctor of Philosophy	Aug 2013
Purdue University School of Civil Engineering	
Master of Science in Transportation Engineering	July 2007
Bangladesh University of Engineering and Technology (BUET)	
Bachelor of Science in Civil Engineering	Nov 2004
Bangladesh University of Engineering and Technology (BUET)	

Employment

- Assistant Professor, University of Central Florida, 2016-present.
- Postdoctoral Research Fellow, Cities Program, CSIRO, Australia, 2013-2016.
- Research Assistant, School of Civil Engineering, Purdue University, 2009-2013.
- Research Assistant, Intelligent Transportation Systems Laboratory, MIT, 2007-2009.
- Research Intern, Road Network Performance Research Group, Transport for London, 2008.

Project Involvement at CSIRO

1. Assessing infrastructure systems resilience and socio-economic impacts of disruptions: Complementary top-down and bottom-up approaches, CSIRO strategic project, Role-PI, July 2015-Aug 2016.
2. Developing resilient infrastructure by distributed systems in Northern Australia's cities, CSIRO strategic project, Role- Co-PI, Jan 2015-June 2015.

Professional Service

- Reviewer: NSF, Transportation Research Part B, C & D, Networks & Spatial Economics
- Member, Institute for Operations Research and the Management Sciences (INFORMS)

Awards and Honors

- Best Dissertation Prize, Transportation Science & Logistics (TSL) Society, INFORMS, 2014.
- Outstanding Graduate Student Research Award, Purdue College of Engineering, 2013.
- Fulbright Science and Technology Fellowship 2007-2010.

Selected Publications

Published work has been cited 470 times in [Google Scholar](#) (**h-index = 12**)

BOOK CHAPTER

1. Ukkusuri, S. V., **Hasan, S.**, and Zhan, X. 2013. Checking the urban pulse: Social media data analytics for transportation applications. *Best Practices for Transportation Agency Use of Social Media*. Editors: Susan Bregman and Kari Edison Watkins. Taylor and Francis/CRC Press.

JOURNAL PUBLICATIONS

1. Ukkusuri, S. V., **Hasan, S.**, Luong, B., Doan, K., Zhan, X., Murray-Tuite, and Yin, W. 2016. A-RESCUE: An Agent based Regional Evacuation Simulator Coupled with User Enriched Behavior. *Networks and Spatial Economics* DOI 10.1007/s11067-016-9323-0.
2. **Hasan, S.** and Ukkusuri, S. V. 2015. Location contexts of user check-ins to model urban geo life-style patterns. *PLoS ONE* 10(5): e0124819.
3. **Hasan, S.** and Foliente, G. 2015. Modeling infrastructure system interdependencies and socio-economic impacts of failure in extreme events: Emerging R&D challenges. *Natural Hazards* 78(3), 1-26.
4. **Hasan, S.** and Ukkusuri, S. V. 2014. Urban activity pattern classification using topic models from online geo-location data. *Transportation Research Part C* 44, 363-381.
5. Collins, C., **Hasan, S.**, and Ukkusuri, S. V. 2013. A novel transit rider satisfaction metric: Rider sentiments measured from online social media data. *Journal of Public Transportation* 16(2), 21-45.
6. **Hasan, S.**, Mesa-Arango, R., and Ukkusuri, S. V. 2013. A random-parameter hazard-based model to understand household evacuation timing behavior. *Transportation Research Part C* 27, 108-116.
7. Mesa-Arango, R., **Hasan, S.**, Ukkusuri, S. V., and Murray-Tuite, P. 2013. Household-level model for hurricane evacuation destination type choice using Hurricane Ivan data. *ASCE Natural Hazards Review* 14(1), 11-20.
8. **Hasan, S.** and Ukkusuri, S. V. 2013. Social contagion process in informal warning networks to understand evacuation timing behavior. *Journal of Public Health Management Practice* 19, S68-S69.
9. **Hasan, S.**, Mesa-Arango, R., Ukkusuri, S. V., and Murray-Tuite, P. 2012. Transferability of hurricane evacuation model: Joint model estimation combining multiple data sources. *ASCE Journal of Transportation Engineering* 138(5), 548-556.
10. **Hasan, S.** and Ukkusuri, S. V. 2011. A threshold model of social contagion process for evacuation decision making. *Transportation Research Part B* 45(10), 1590-1605.
11. **Hasan, S.**, Ukkusuri, S. V., Gladwin, H., and Murray-Tuite, P. 2011. Behavioral model to understand household-level hurricane evacuation decision making. *ASCE Journal of Transportation Engineering* 137(5), 341-348.

TECHNICAL REPORTS

1. **Hasan, S.** and Foliente, G. 2014. Modelling infrastructure interdependencies and assessing socio-economic impacts of disruptions caused by extreme events. CES Highett, CSIRO Report to the Climate Adaptation Flagship, 38 pp, csiro: EP145500.